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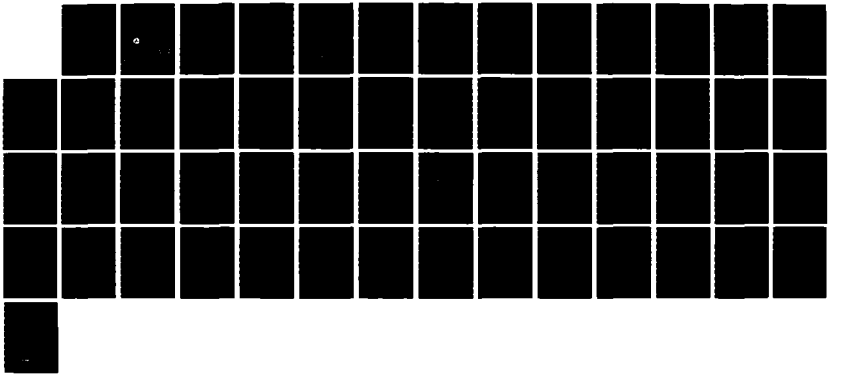

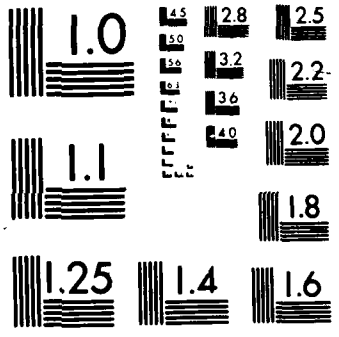
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Report No. CG-D-22-86

HAZARDOUS SELECTION OF PRIORITY CHEMICALS FOR PERMEATION TESTING AND HAZARDOUS CHEMICAL SPILL DETECTION AND ANALYSIS

DR. MARTHA S. HENDRICK
and
CLARE B. BILLING, JR.

U.S. COAST GUARD RESEARCH AND DEVELOPMENT CENTER
AVERY POINT, GROTON, CONNECTICUT 06340-6096

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16. Abstract

This report describes the use of a relational data base for the selection of priority hazardous chemicals to give a reasonable starting point and a logical sequence for conducting development programs involving chemical pollutants. The chemicals considered for the data base in this report are those that are most likely to be encountered in or near a marine environment. The first task required identification of those chemicals to which protective clothing is to be exposed. For the second task, a priority list was needed for the development of identification, classification, and quantification response techniques. The strategy was to gather information on spill incidence, chemical hazards, and need for clothing protection associated with each chemical. This information was compiled from a variety of sources and stored in the Chemical Hazard Information Files (CHIFs) data base using a computer and commercially available data base management software. Selection criteria were established for each task and documented along with sources of information, CHIFs data base structure, programs to enter and sort information, and the hazardous chemical priority lists.

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UNCLASSIFIED	UNCLASSIFIED		

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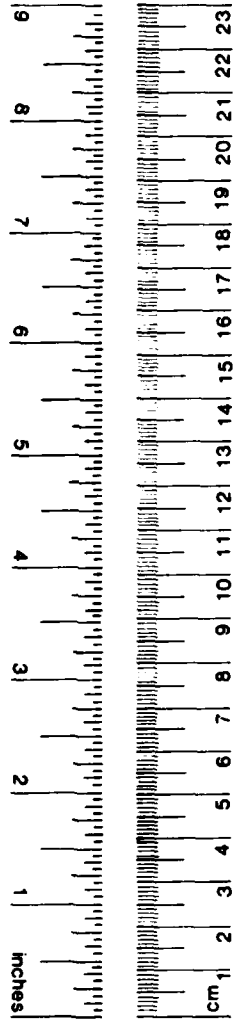
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

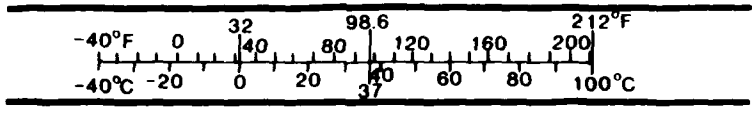
Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
in	inches	* 2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (WEIGHT)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (EXACT)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

* 1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures. Price $2.25. SD Catalog No. C13.10:286



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (WEIGHT)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (EXACT)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

The purpose of this study was the selection of the highest priority hazardous chemicals in the marine environment. The Priority Chemical Lists are to be used for further research in two Coast Guard Project areas: Hazardous Chemical Protective Clothing (4155) and Chemical Analysis for Pollution Response and Law Enforcement (4154). Objectives of this report are to publish the Priority Chemical Lists and to document the sources and selection criteria which were used in the selection of the chemicals. Equally important is to describe the methodology used for establishing a data base to sort chemical data - with the hope that it will provide a useful model for the application of chemical data base management for project decision-making and evaluation.

The selection of priority hazardous chemicals requires objective criteria with which to rank chemicals. The storage, organization, and manipulation of information are functions that are ideally suited for computers. With commercially available data base management programs, information on hazardous chemicals can be organized, stored, and sorted. The selection criteria, however, must be provided by the data base user. The usefulness of the results depends on both the quality of the information which is entered and the selection criteria that are used. By automating the process of sorting data, a data base management system gives the user the freedom to evaluate different selection criteria, to combine the selection criteria in various ways, and to handle large amounts of data with little additional effort. Modification of the list of chemicals is easily accomplished if new sources of information are identified. Because spills of different hazardous chemicals are not expected to occur with the same frequency, it is important to have the ability to evaluate and update the list periodically to reflect trends over time.

The data base was designed to accomplish project goals. To accomplish these goals most efficiently, we have relied on secondary sources of

information compiled by the Coast Guard and other government agencies. Information on hazardous chemicals was selected for its relevance to the research projects underway at the Coast Guard Research and Development (R&D) Center. The purpose was not to provide or maintain a source of information for general use by the public. The general approach we have used can be adapted to many applications and will be described in detail.

This report does not document the developmental history of the priority lists, but it does include the sources used, the current structure of the data base, and the selection criteria developed for each priority list.

DEVELOPMENT OF THE CHEMICAL HAZARD INFORMATION FILE (CHIFs) DATA BASE

The selection of hardware and software was determined by availability. Because the scope of the data base work did not justify a dedicated computer, computers at the R&D Center were examined for their capability to perform these tasks, with access to the computer a primary consideration. The best choice was an HP 9000 series multiuser computer located in the Marine Fire Research Branch (MFRB). A terminal for this computer was located in the Chemistry Branch and was available on a part-time basis for the CHIFs data base work. Data base management software was also available through MFRB. Table I lists the specifications for Informix [2], the data base management software used for these studies. The storage capacity of the software far exceeded the needs anticipated for CHIFs; no more than the 1100 CHRIS list chemicals, and a far smaller number of sources of information for each chemical would be included. In addition, the number of logical statements that could be handled in each sorting procedure was far greater than the capability of data base programs for smaller computers. Unlike personal computer data base software, this data base management system required programming to define the structure of the data base, format the data base entry screens, and generate reports from the data base. This inconvenience is more than offset by the storage capacity as well as by the flexibility offered by the relational data base. This data base software can also expand or

Table I

INFORMIX Specifications

GENERAL DATABASE SPECIFICATIONS (Maximum specifications except as noted)	
Number of files per database	UNLIMITED
Number of fields per database	UNLIMITED
Number of records per file	UNLIMITED
Record size	2048 bytes
Number of fields per record	2048
Field Size	2048
Number of secondary indexes	UNLIMITED
Size of composite keys	120 bytes, 1-8 fields

modify the structure of an existing data base. The CHIFs data base was expanded as additional sources of information were identified and made available; it can be updated from year to year.

The CHIFs data base was modified in the course of its development to include additional sources of information by expanding the number of files within the data base. The data base as of March 1986 included six files containing information on:

1. Chemical hazard and spill history information

2. NOAA Chemical Advisory Report System

3. National Response Center spill reports (1985)

4. Permeation Test Method Information

5. Protective Clothing Material Product Information

6. Permeation Test Results

Each file contains separate fields for different types of information within it. The fields within the first file contain information on chemical hazards and spill history and are shown in Table II. This was the original file to be established. A more complete description of the fields is included in Appendix A.

Special programs to format the screen for data entry speed the data entry process. These clearly identify each item to be entered, and where the information is to be stored in the data base. Options are available for checking the data and entering default values. Appendix B includes a sample program to illustrate screen entry as well as copies of the programs used for this work.

TABLE II

CHEMICAL HAZARD AND SPILL HISTORY INFORMATION FILES

Field	Contents	Information Sources
1	Chemical Name	From References
2	CHRIS Code	Coast Guard's Chemical Hazard Response Information System (CHRIS) (1)
3	Physical State	CHRIS Manual (1)
4	CHRIS Class	CHRIS Manual (1)
5	R&D Class	Table A-1
6	Permeation Class	Guidelines for the Selection of Chemical Protective Clothing (3)
7	Hazard Assessment Index	Marine Hazardous Substance Data System (4)
8	Skin Toxicity	Marine Hazardous Substance Data System (4)
9	Health Rating	NFPA (5)
10	Fire Rating	NFPA (5)
11	Chemical Reactivity	NFPA (5)
12	Requirement for Totally Encapsulated Suit	"Material Development Study for Hazardous Chemical Protective Clothing Outfit" (6)
13	PIRS Spills, '79-'83	Pollution Incident Reporting System (7)
14	PIRS Spills, '73-'79	Pollution Incident Reporting System (8)
15	Spill Incidents	Portable Device For Detecting and Identifying Hazardous Vapors (9)
16	Spill Incidents	NOAA Scientific Support Coordinator's Reports 1984 (internal reports)
17	Spill Reports	CG Marine Safety Offices (internal reports)
18	CG Strike Team Reports (1984)	Internal Reports
19	Spills - MSO Detroit	Internal Reports
20	Results of 1979 Priority List for Project 4154	Internal Reports
21	Results of Priority List for Project 4155 (Top 117 chemicals) and 4154	Output from Data Base Programs

SELECTION OF PRIORITY HAZARDOUS CHEMICALS FOR PERMEATION TESTING

Background

The U.S. Coast Guard personnel use chemical protective clothing in responding to hazardous chemical spill incidents. The Coast Guard is in the process of developing new totally encapsulating suits, and it is important that the protective clothing material that is selected be compatible with the chemicals to which it will be exposed. For this reason, the Chemistry Branch at the Coast Guard R&D Center was assigned the project of testing and evaluating prospective suit materials. The scope of this project and the details of permeation testing have been described (10). One aspect of the project involves testing the protective clothing material's resistance to chemicals selected from CHRIS. The CHIFS data base was developed and used to expedite this selection process. The ultimate outcome of this research will be a suit user's manual to guide response personnel in selecting the appropriate suit for the specific chemical environment.

Selection Criteria

Selecting a smaller subset of priority chemicals for actual testing requires a process of decision-making regarding criteria that should be used to sort the chemicals into groups and then to assign priority. Figure 1 shows the groups into which chemicals were sorted. The x-axis indicates if the chemical has a spill history reported by any references in the data base. The y-axis shows whether the chemical was recommended for inclusion in the list of chemicals for which the Coast Guard requires a totally encapsulating suit (6). A third criterion for grouping the chemicals is based on what we call the hazard level of the chemical. This criterion combines several factors to group chemicals into one of three of the following levels:

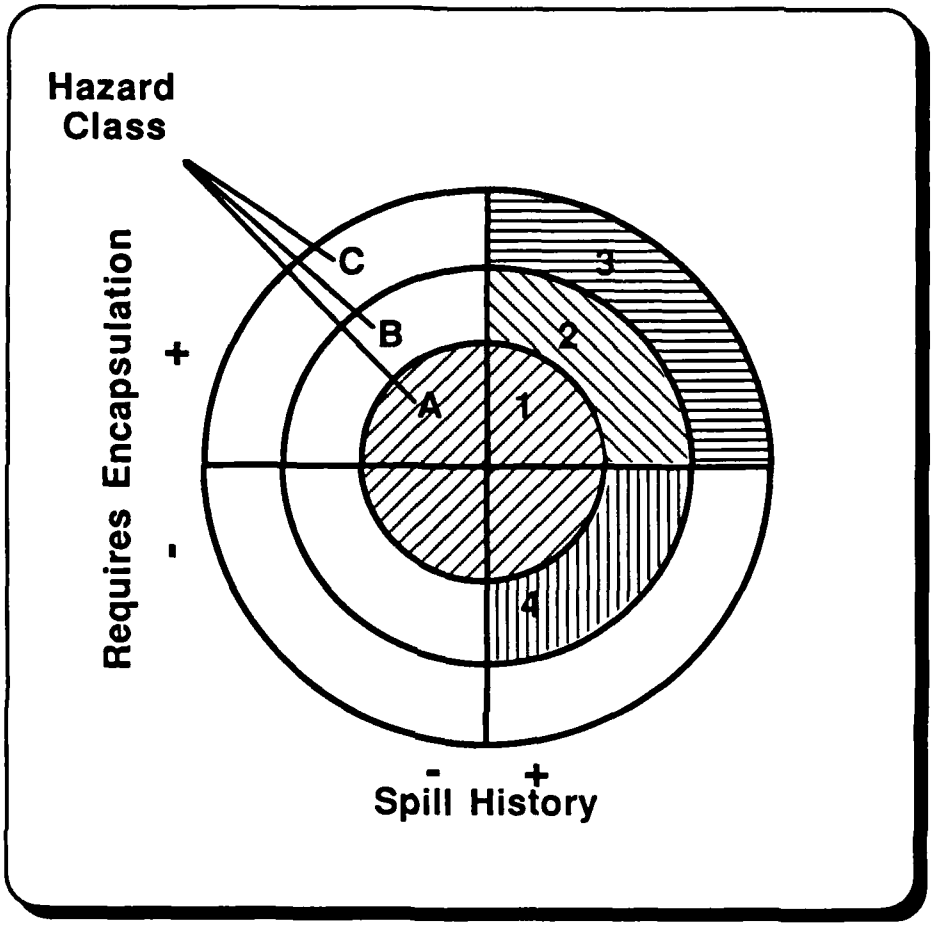

FIGURE 1. - SELECTION CRITERIA USED FOR PRIORITY HAZARDOUS CHEMICALS PERMEATION TESTING

Level A: The chemical has been assigned either a carcinogen class "1" or highly toxic "2", or toxic through skin absorption "S" in the Hazard Assessment Index (4), or the NFPA has assigned it a "4", its highest health hazard rating (5).

Level B: A hazard Assessment Index of "3" or a NFPA rating of "3".

Level C: Other chemicals not in A or B.

A fourth criterion, the physical state of the material at room temperature, was later added so that liquids could be selected first for testing by the ASTM standard method, F-739-85, which applies only to permeation tests with liquids. The priority list which was generated for initial permeation testing includes only liquid chemicals, as discussed above.

Programs for Sorting Chemicals

Computer programs generated reports which divided the chemicals into groups. These were written according to the simple high level commands described in the Informix User's Manual (2). These programs are presented in Appendix C.

List of Hazardous Chemicals for Permeation Testing

The 116 chemicals selected for permeation testing are listed in Table III in alphabetical order by CHRIS code. The list includes Threshold Limit Values, the concentrations to which 8-hour exposures are considered safe. A listing of the chemicals sorted into groups is included in Appendix D. The rationale behind this selection process is based on combining two primary considerations: health hazards and spill history.

The groups which were selected for testing, in order of priority, are indicated by number on Figure 1:

TABLE III

Priority Chemicals for Permeation Testing
Listed in Alphabetical Order

CHRIS	CHEMICAL NAME	TLV (mg/m^3)
AAC	acetic acid	25.00
AAD	acetaldehyde	180.00
ACA	acetic anhydride	20.00
ACC	acetyl chloride	20.00
ACN	acrylonitrile	4.50
ACR	acrylic acid	30.00
ACT	acetone	1780.00
ACY	acetone cyanohydrin	
ADN	adiponitrile	
ALA	allyl alcohol	5.00
ALC	allyl chloride	3.00
ANL	aniline	10.00
ARL	acrolein	0.25
ATN	acetonitrile	70.00
BAM	n-butylamine	15.00
BAN	n-butyl alcohol	150.00
BCL	benzyl chloride	5.00
BCN	n-butyl acetate	710.00
BNZ	benzene	30.00
BRX	bromine	0.70
BTC	n-butyl acrylate	55.00
BTR	n-butyraldehyde	
BUA	t-butyl amine	15.00
CBB	carbon disulfide(bisulfide)	3.00
CBT	carbon tetrachloride	12.00
CCT	creosote	0.10
CDN	chlordane	0.50
CHX	cyclohexane	1050.00
CMH	cumene hydroperoxide	
CPL	chloropicrin	0.70
CRB	chlorobenzene	350.00
CRF	chloroform	50.00
CRS	cresol	22.00
CSA	chlorosulfonic acid	
CSS	sodium hydroxide solution(caustic soda)	2.00
CTA	crotonaldehyde	6.00
DCM	methylene chloride	261.00
DEA	diethanolamine	15.00
DEE	dichloroethylether	30.00
DIA	diisopropylamine	20.00
DNA	di-n-propylamine	

TABLE III (continued)

CHRIS	CHEMICAL NAME	TLV (mg/m^3)
DOX	1,4-dioxane	3.60
DPC	1,3-dichloropropene	5.00
DPP	dichloropropane	300.00
DSF	dimethyl sulfate	0.50
EAC	ethyl acrylate	20.00
EAL	ethyl alcohol	1900.00
EAM	ethylamine	18.00
EDA	ethylenediamine	25.00
EDB	ethylene dibromide	1.00
EDC	ethylene dichloride	20.00
EET	ethyl ether	1200.00
EGL	ethylene glycol	125.00
EPC	epichlorohydrin	10.00
ETA	ethyl acetate	1400.00
ETB	ethyl benzene	435.00
ETO	ethion	0.40
FFA	furfural	8.00
FMS	formaldehyde	1.50
GAT	gasoline	900.00
GTA	glutaraldehyde	0.70
HCN	hydrogen cyanide	11.00
HDZ	hydrazine	0.10
HFA	hydrofluoric acid	2.50
HFX	hydrogen fluoride	2.50
HPO	hydrogen peroxide |60%	1.50
HXA	n-hexane	180.00
IPA	isopropyl alcohol	980.00
IPP	isopropylamine	12.00
MAL	methyl alcohol	260.00
MAM	methyl acrylate	35.00
MEK	methyl ethyl ketone	590.00
MFA	motor fuel anti-knock compounds (lead alkyls)	0.07
MIK	methyl isobutyl ketone	200.00
MLT	malathion	10.00
MMM	methyl methacrylate	410.00
MPT	methyl parathion mp=65F	0.20
MTC	methyl chloride	105.00
NAC	nitric acid	5.00
NLD	naled	3.00
NPP	2-nitropropane	35.00
NSS	naptha	400.00
NTB	nitrobenzene	5.00
NTM	napthalene	50.00
OLM	oleum	1.00
PAC	phosphoric acid	1.00
PAL	n-propyl alcohol	500.00
PCB	polychlorinated biphenyl compounds	0.001

TABLE III (continued)

CHRIS	CHEMICAL NAME	TLV (mg/m^3)
PHN	phenol	19.00
PNA	propionic acid	30.00
POX	propylene oxide	50.00
PPO	phosphorus oxychloride	0.60
PPT	phosphorus trichloride	1.50
PRA	n-propyl amine	
PTO	parathion	0.10
SFA	sulfuric acid	1.00
SFM	sulfur monochloride	6.00
SHD	caustic soda (sodium hydroxide)	2.00
SHR	sodium hydrosulfide solution	
STC	silicon tetrachloride	
STY	styrene	420.00
TCL	trichloroethylene	270.00
TDI	toluene diisocyanate	0.04
TEC	1,1,2,2-tetrachloroethane	7.00
TCE	trichloroethane	900.00
TEL	tetraethyl lead	0.07
TEP	tetraethyl pyrophosphate	
TLI	o-toluidine	9.00
TML	tetramethyl lead	0.07
TOL	toluene	750.00
TPT	turpentine	560.00
TTE	tetrachloroethylene	670.00
VAM	vinyl acetate	15.00
VCI	vinylidene chloride	4.00
XLM	xylene	435.00
XYL	xylenol	

There are a total of 116 chemicals

1. All the chemicals at Hazard Level A. Only 12 of these chemicals had not been included on the encapsulated suit list (6). A decision was made to include them as a backup to provide an additional margin of safety by not relying solely on one source for hazard evaluation. This group included 51 chemicals.

2. Hazard Level B chemicals with both an encapsulated suit requirement and a spill history. There were 24 chemicals in this group.

3. Fourteen chemicals which had both a spill history and an encapsulated suit requirement, although they had not been included in Hazard Level A or B.

4. Chemicals were in Hazard Level B with a spill history that had not previously been selected in one of the above groups.

Group 1 contains all the liquid chemicals which cause the most serious problems (to the extent we can determine), whether they have ever been spilled or not. Groups 2 and 3 include all those chemicals which need totally encapsulated suits (6) if they have a spill history. Group 4 chemicals are toxic and have a spill history.

For chemicals not tested, other chemical class respresentatives in the data base can give reliable estimates of permeation properties. Other tasks within the permeation project address more fundamental aspects of permeation, so that projections of the permeation characteristics for other chemicals can be based on the results of this subset of high priority chemicals.

HAZARDOUS CHEMICAL PRIORITY LIST FOR ANALYSIS FOR POLLUTION RESPONSE AND LAW ENFORCEMENT

Background

The purpose of this project is to evolve a rapid response capability to classify, identify, and quantify spilled chemicals in the marine environment. Analytical techniques useful for either the field or the laboratory must be developed. Analytical method development is a complex process, and it is not possible, at the present time, to develop one simple technique by which every chemical can be analyzed (11). For this reason, one element of this project, from the beginning, has been to establish a priority ranking of hazardous chemicals present in or near the marine environment. The objective was to identify those chemicals posing the greatest threat to people and/or the environment. A Priority List (12) for Project 4154 was selected in 1979. The selection criteria included chemicals that could be shipped by water. However, the list of over 400 chemicals was not stored on computer and did not rank chemicals. The current project seeks to select a smaller number of priority chemicals and rank them based on information about chemical hazards and spill frequency.

Selection Criteria

After the priority list for Permeation Testing was completed, additional information was acquired. The Hazardous Materials Response Branch of the National Oceanic and Atmospheric Administration (NOAA) maintains files of computerized information on hazardous chemicals (CHEMREPS), which have been described by Ernst (13). These are transmitted to NOAA scientific support coordinators in the field, who assist the Coast Guard in spill situations. A separate file was created in the data base for CHEMREP information. This file contains fields for chemical names, information on whether the chemical had been encountered in a real spill, and whether the chemical is planned for inclusion, but not yet a part of the CHEMREP system. The NOAA CHEMREPS were used an indication of whether a serious spill had occurred.

Other sources used for the 4154 priority list included the Hazardous Index (4) and whether or not the chemical was reported to the Pollution Incident Reporting System (PIRS) (7,8). For a Hazard Index of 1 (carcinogens), or 2 (very toxic), relatively few spill incidents were required to justify inclusion on the priority list. Either inclusion on the CHEMREP list as a spill or a PIRS report will identify the chemical for selection. At a hazard assessment index of 3 (toxic hazard) and above, the criteria are more restrictive. The criteria for each level of hazard index are shown in Table IV.

Priority List Chemicals

Eighty-one (81) chemicals were selected based on the criteria discussed above; one was added in the evaluation process (see below). These chemicals are included in Table V, and they account for 92% of the 1,303 PIRS spills of hazardous chemicals compiled for 1973-1983. The top 25 chemicals shown in Table V account for 82% of the reported spill incidents. Table VI shows the ranking of these substances based on their hazard index and physical state. Six solids, 11 gases, and 65 liquids are represented. The hazard indices indicate that many of these chemicals are extremely toxic.

Evaluation of the Priority List

Past spills of chemicals may indicate that a chemical is more likely to be spilled in the future, but this is by no means a certainty. We compared our 4154 Priority List to a list of chemicals which had been spilled in 1985, as compiled by the National Response Center (NRC). The NRC list contained many petroleum oils, which we excluded from consideration because the Coast Guard has an Oil Identification Laboratory with established analytical protocols (13). The NRC list also included all incidents, not just those to which the Coast Guard had responded. Although separating Coast Guard responses for the

TABLE IV

CRITERIA FOR SELECTING PRIORITY LIST CHEMICALS

HAZARD ASSESSMENT INDEX[a]	CHEMREP[b]	PIRS ('73-'83) (# of spills)	PIRS ('73-'79) (% of Total)
1 (CARCINOGENS)	+	>0	>0
2 (HIGH TOXIC HAZARD)	+	>0	>0
3 (TOXIC HAZARD)	+	≥1	
	+		≥0.1
	-	≥4	
OTHER (INCLUDING UNCLASSIFIED)			
	+	≥5	
	-	≥10	
	-		≥0.1

a For Hazard Assessment Indices of 1 or 2, appearance on CHEMREP list or any reported spill automatically selects the chemical. For an Index of 3 or Other, only two conditions need to be met.

b Either listed at present or planned to be included in compilation of chemicals to which NOAA has responded.

TABLE V

4154 PRIORITY LIST HAZARDOUS CHEMICALS

In order of Spill Frequency

CHRIS	CHEMICAL NAME	PIRS SPILLS
SFA	sulfuric acid	128
SHD	caustic soda (sodium hydroxide)	95
PCB	polychlorinated biphenyl compounds	92
XLM	xylene	92
BNZ	benzene	91
AMA	ammonia	85
TOL	toluene	81
HCL	hydrochloric acid	63
STY	styrene	59
CLX	chlorine	35
CRL	cresol	33
PHN	phenol	26
EGL	ethylene glycol	23
PAC	phosphoric acid	22
FMS	formaldehyde	17
CHX	cyclohexane	17
MTC	methyl chloride	15
AAC	acetic acid	13
TTE	tetrachloroethylene	12
ACN	acrylonitrile	12
ACT	acetone	11
EAC	ethyl acrylate	11
MAL	methyl alcohol	11
ACR	acrylic acid	10
NTM	napthalene	10
EAL	ethyl alcohol	9
NAC	nitric acid	8
VAM	vinyl acetate	8
VCI	vinylidene chloride	8
ALM	aluminum sulfite	7
CBT	carbon tetrachloride	6
HFA	hydrofluoric acid	6
MEK	methyl ethyl ketone	6
TCL	trichloroethylene	5
EDA	ethylenediamine	5
MIK	methyl isobutyl ketone	5
TPT	turpentine	5
AAD	acetaldehyde	4
DCM	methylene chloride	4
HXA	n-hexane	4

TABLE V (continued)

CHRIS	CHEMICAL NAME	PIRS SPILLS
TCE	trichloroethane	4
CRF	chloroform	3
EAM	ethylamine	3
PPW	phosphorus	3
ETB	ethyl benzene	3
MMM	methyl methacrylate	3
ANL	aniline	2
ACA	acetic anhydride	2
ATN	acetonitrile	2
ALA	allyl alcohol	2
DEA	diethanolamine	2
MLA	maleic anhydride	2
BAN	n-butyl alcohol	2
BCL	benzyl chloride	1
BTY	butyl amine	1
CSA	chlorosulfonic acid	1
DMA	dimethylamine	1
EPC	epichlorohydrin	1
NTB	nitrobenzene	1
POX	propylene oxide	1
LNG	liquid natural gas	0
LPG	liquid petroleum gas	0
TEC	1,1,2,2-tetrachloroethane	0
ALC	allyl chloride	0
BDI	1,3 butadiene	0
CBB	carbon disulfide(bisulfide)	0
DIA	diisopropylamine	0
DPM	diphenylmethane diisocyanate	0
EDB	ethylene dibromide	0
EDC	ethylene dichloride	0
EOX	ethylene oxide	0
HDC	hydrochloride gas (HCl)	0
HFX	hydrogen fluoride	0
IPP	isopropylamine	0
MTB	methyl bromide	0
TLI	o-toluidine	0
SFD	sulfur dioxide	0
TDI	toluene diisocyanate	0
VCM	vinyl chloride	0
BAM	n-butylamine	0
IPA	isopropyl alcolol	0
AMN	ammonium nitrate	0

TABLE VI

4154 PRIORITY LIST HAZARDOUS CHEMICALS

Grouped into solids, liquids, and gases and listed by hazard index

CHRIS CODE	CHEMICAL NAME	PHYSICAL STATE	HAZARD INDEX
BDI	1,3 butadiene	g	1
EOX	ethylene oxide	g	1
VCM	vinyl chloride	g	1
AMA	ammonia	g	2
CLX	chlorine	g	2
DMA	dimethylamine	g	2
HDC	hydrochloride gas (HCl)	g	2
MTB	methyl bromide	g	2
SFD	sulfur dioxide	g	2
LNG	liquid natural gas	g	5
LPG	liquid petroleum gas	g	n
ACN	acrylonitrile	l	1
BNZ	benzene	l	1
CBT	carbon tetrachloride	l	1
CRF	chloroform	l	1
EDB	ethylene dibromide	l	1
FMS	formaldehyde	l	1
TLI	o-toluidine	l	1
TEC	1,1,2,2-tetrachloroethane	l	2
ALC	allyl chloride	l	2
ANL	aniline	l	2
BCL	benzyl chloride	l	2
BTY	butyl amine	l	2
CBB	carbon disulfide(bisulfide)	l	2
CSA	chlorosulfonic acid	l	2
DIA	diisopropylamine	l	2
EPC	epichlorohydrin	l	2
EAM	ethylamine	l	2
EDC	ethylene dichloride	l	2
HCL	hydrochloric acid	l	2
HFA	hydrofluoric acid	l	2
HFX	hydrogen fluoride	l	2
IPP	isopropylamine	l	2
MTC	methyl chloride	l	2
NAC	nitric acid	l	2
NTB	nitrobenzene	l	2
PHN	phenol	l	2
POX	propylene oxide	l	2
STY	styrene	l	2

TABLE VI (continued)

CHRIS CODE	CHEMICAL NAME	PHYSICAL STATE	HAZARD INDEX
TDI	toluene diisocyanate	l	2
TCL	trichloroethylene	l	2
VAM	vinyl acetate	l	2
VCI	vinylidene chloride	l	2
BAM	n-butylamine	l	2
AAD	acetaldehyde	l	3
AAC	acetic acid	l	3
ACA	acetic anhydride	l	3
ACT	acetone	l	3
ATN	acetonitrile	l	3
ACR	acrylic acid	l	3
ALA	allyl alcohol	l	3
CRL	cresol	l	3
CHX	cyclohexane	l	3
DEA	diethanolamine	l	3
EAC	ethyl acrylate	l	3
EAL	ethyl alcohol	l	3
ETB	ethyl benzene	l	3
EGL	ethylene glycol	l	3
EDA	ethylenediamine	l	3
IPA	isopropyl alcolol	l	3
MAL	methyl alcohol	l	3
MEK	methyl ethyl ketone	l	3
MIK	methyl isobutyl ketone	l	3
MMM	methyl methacrylate	l	3
DCM	methylene chloride	l	3
BAN	n-butyl alcohol	l	3
HXA	n-hexane	l	3
NTM	napthalene	l	3
PAC	phosphoric acid	l	3
SFA	sulfuric acid	l	3
TOL	toluene	l	3
TCE	trichloroethane	l	3
TPT	turpentine	l	3
XLM	xylene	l	3
PCB	polychlorinated biphenyl compounds	l	n
TTE	tetrachloroethylene	l	n
DPM	diphenylmethane diisocyanate	s	2
PPW	phosphorus	s	2
SHD	caustic soda (sodium hydroxide)	s	3
MLA	maleic anhydride	s	3
ALM	aluminum sulfite	s	n
AMN	ammonium nitrate	s	n

There are a total of 82 chemicals; there are 11 gases, 65 liquids and 6 solids.

entire year was not possible, the Coast Guard generally responds to fewer discharges of gases, and more to spills into water, than other agencies (14). The list of NRC incidents was entered into a separate file in the data base, and the spills ordered according to frequency. Disregarding oils, multiple, and unknown spills, the five most frequently spilled - or discharged - chemicals in 1985 were PCBs, sulfuric acid, ammonia, chlorine, and hydrochloric acid. These five chemicals accounted for 1362 of the 2882 hazardous chemical spills, or 47% of the known, non-petroleum related incidents. These same hazardous chemicals were also in the top 10 frequently spilled chemicals on the PIRS compilation, accounting for 34% of the PIRS hazardous chemical spills. The difference is due to the increase in the number of PCB incidents reported to the NRC. Of the top 25 NRC spills- excluding asphalt, creosote, jet fuel, kerosene, and petroleum oils- shown in Table VII, twenty-one are on the 4154 hazardous chemical spill priority list. The compounds which we had included on the priority list accounted for 68% of the total number of NRC incidents. The 81 chemicals selected for the 4154 priority list account for 77% of the hazardous chemical spills reported to the National Response Center in 1985.

The Environmental Protection Agency (EPA) has independently compiled an "Acute Hazardous Events Database", which was based on a much more serious extensive survey (15). The results are consistent with our observation that a few hazardous chemicals are involved in a disproportionately high percentage of spill incidents. The EPA data base includes all spills, in industrial settings as well as transportation incidents; transportation-related spills accounted for only 35% of the total spill incidents. The pattern is the same: 58% of all incidents involved only 20 substances. PCBs were involved in the greatest number of incidents. The EPA data base included data on incidents which had caused death or injury. Chlorine, ammonia, hydrochloric acid, and sulfuric acid were involved most frequently in these serious incidents. These chemicals were also at the top of the NRC list and in the top ten of our priority list.

TABLE VII

MOST FREQUENTLY SPILLED CHEMICALS REPORTED TO THE NATIONAL RESPONSE CENTER

NRC-CHRIS comparison for CHIFs chemicals

CHRIS CHEMICAL NAME	HAZARD CODE	PIRS	NRC (1985)
PCB polychlorinated biphenyl compounds	n	92	708
SFA sulfuric acid	3	128	216
AMA ammonia	2	85	161
CLX chlorine	2	35	158
HCL hydrochloric acid	2	63	119
MTC methyl chloride	2	15	87
EOX ethylene oxide	1	0	66
*SHD caustic soda (sodium hydroxide)	3	95	63
*CSS sodium hydroxide solution(caustic soda)	3	0	44
TCE trichloroethane		0	42
TTE tetrachloroethylene	n	12	40
EAL ethyl alcohol	3	9	38
TOL toluene	3	81	33
LPG liquid petroleum gas	n	0	33
PAC phosphoric acid	3	22	32
VCM vinyl chloride	1	0	32
STY styrene	2	59	29
MAL methyl alcohol	3	11	27
HDS hydrogen sulfide		0	27
DCM methylene chloride	3	4	23
NAC nitric acid	2	8	22
BNZ benzene	1	91	21
ACT acetone	3	11	19
TCL trichloroethylene	2	5	18
MCR mercury		0	16

* Combined on 4154 Priority List as sodium hydroxide.

Examination of the chemicals on the NRC list reveals that ammonium nitrate was involved in 14 incidents in 1985. NOAA had included it in the CHEMREPS. NOAA response personnel indicated that this chemical has been involved in spills into waterways, where it can pose serious problems. Examination of the original data base sources suggest that it was probably omitted because "ammonium compounds" were not individually identified, therefore they were not included on the list of CHRIS chemicals. Ammonium nitrate was added to the priority list, increasing the number of compounds to 82. Tables V and VI reflect the addition of this compound.

The correspondence of the 4154 priority list with the NRC and EPA lists confirm the value of our strategy of identifying the most serious problem chemicals and concentrating development efforts in the areas which will be most beneficial.

CONCLUSIONS AND FUTURE WORK

The CHIFs data base has been a helpful tool for information storage and retrieval in formulating lists of priority hazardous chemicals for further research. Work which will be based on these priority lists include:

1. Evaluating the 4154 priority list on a regular basis to identify chemicals which may be increasing in frequency of spillage.

2. Evaluating analytical methods for hazardous chemical response situations. This evaluation will screen methods for their capability of a rapid analytical response, or turn-around-time, either in the field or in the laboratory. This evaluation will begin with the most frequently spilled chemicals and extend to the entire 4154 priority list. The results will be available for use in the field through the NOAA Hazardous Material Spill Response System.

3. The chemicals selected for permeation testing for project 4155 have been contracted to a private contract laboratory for routine testing. The results of this study will be used to prepare a manual for the use of the new totally encapsulated suits developed by the Coast Guard.

4. Results of permeation testing will be stored in a separate file in the data base and transmitted via computer to a data base of permeation results which is being compiled by the National Institute for Occupational Safety and Health (NIOSH). The data will also be sent directly to Coast Guard Headquarters.

REFERENCES

1. Chemical Hazards Response Information Systems, Commandant Instruction M16465.11, (September 1985), U.S.G.P.O., Washington, D.C.

2. Informix User's Manual, Relational Data Base Systems, Inc., (Menlo Park, CA), 1984, p. 16.

3. Guidelines for the Selection of Chemical Protective Clothing, 2nd Edition, American Conference of Governmental Industrial Hygienists, Inc., 6500 Glenway Avenue, Bldg. D-7, Cincinnati, OH 45211, 1985.

4. Marine Hazardous Substance Data System, SWRI Project 06-7223 (October 1984).

5. "Fire Protective Guide on Hazardous Materials", Code 704M, 4th Edition, National Fire Protection Association, Boston, MA, 1972.

6. Friel, J.V., McGoff, M.J., and S.J. Rodgers, "Material Development Study for Hazardous Chemical Protective Clothing Outfit," CG-D-58-80, MSA Research Corp., Evans City, PA (Aug 1980) (ADA 095-993).

7. Stull, J.O., "Consideration on the Development of a Hazardous Chemical Personnel Protection System", Presented at the Second Annual Technical Seminar on Chemical Spills, Toronto, Canada, February 5-7, 1985.

8. Fang, Paul. C.I., et. al., "Analysis of Hazardous Chemical Spills Along the Coasts and Major Waterways of the United States", CG-123-1, (1981).

9. Stetter, J.R., et.al., and A.J. Sinclair, "Portable Device for Detecting and Identifying Hazardous Vapors," Proceedings of the 1984 Hazardous Materials Spill Conference, April 9-12, 1984.

10. Stull, J.O., Man, V.L., Bastecki, V.A., and Bentz, A.P., "A Comprehensive Materials Evaluation Program to Support the Development and Selection of Chemical Protective Clothing", Proceedings of the 1986 Hazardous Materials Spills Conference, St. Louis, MO, May 5-8, 1986.

11. Hendrick, M.S. and Jadamec, J.R., Selecting Analytical Methods for Hazardous Chemical Spills. Proceedings of the 1986 Hazardous Materials Spills Conference, St. Louis, MO, May 5-8, 1986.

12. Coast Guard Priority List, Internal Report enclosed with Annual Project (704154.1). Summary 11 October 1979.

13. Ernst, William D., "NOAA's Chemical Advisory Report (CHEMREP) System for Spill Responses", Proceedings of the 1984 Hazardous Material Spills Conference, Nashville, TN, April 5-9, 1984.

14. "Oil Spill Identification System", Chemistry Branch, USCG R&D Center, June 1977, ADA 044750.

15. Private communication LT HANEWICH, National Response Center.

16. Hazardous Materials Intelligence Report (11 Oct 1985), Vol. VI, No. 41, p.1.

APPENDIX A

STRUCTURE OF THE DATA BASE

The first 19 fields shown in Table II in the Chemical Hazard and Spill History Information File store three types of information:

1) Identification and Classification

2) Chemical Hazard Information

3) Spill History

The first field contains the name referred to in other sources of information. For identification purposes, this must be a unique name, so synonyms for the same name were consolidated under one name.

The CHRIS Code from the Coast Guard's Chemical Hazard Response Information System (Field 2) is a unique identifier for all chemicals and chemical mixtures listed in the CHRIS manual (1). The data base is structured so that two records of information cannot have the same CHRIS code. The CHRIS code was used to check that two names for the same chemical had not been entered. The physical state of the chemical at room temperature was entered in field three. Whether the compound is a solid, liquid, or gas at room temperature was taken from the CHRIS manual. Classification into chemical groups is in fields four through six. The R&D Class (field 5) is a previously developed internal classification system and is shown in Table A-1. The permeation class is a classification scheme proposed to the ASTM as a way of organizing chemicals into groups for reporting permeation results. This proposal is based on a three digit code assigned to the classification groups for organic chemicals in the Kodak catalogue. A listing can be found in Reference (3).

Hazard information is contained in fields 7 through 12.

Table A-1

R&D Center
Chemical Classification Scheme

1. Pesticides
2. Monomers
3. Inorganic acids
4. Inorganic caustics
5. Inorganic halogen compounds
6. Other inorganic cations and anions
7. Saturated hydrocarbons
8. Unsaturated hydrocarbon
9. Halogenated organics
10. Alcohols
11. Aldehydes and keytones
12. Glycols and epoxides
13. Carboxylic acid and derivatives
14. Nitriles and isocyanates
15. Amines and imines
16. Organic sulfur compounds
17. Aromatics
18. Organometallics and organosilicons
19. Phenol
20. Nitro cpds
21. Heterocyclic cpds
22. Phosphorous cpds
23. Ether
24. Peroxides
25. Oils

The totally-encapsulated suit requirement was entered into field 12 as a yes or no, based on information in Reference (6). This information also reflects the degree of hazard of a compound. Because this encapsulated suit information is important to Coast Guard operations in the field, all the chemicals for which such protection is needed were entered into the data base. No primary sources were used for hazard information; several sources which had examined the toxicological and health hazard information were relied upon for judgments which our study did not have the expertise or resources to duplicate.

Spill history was based on a number of different sources, and entered into fields 13 through 17. The CHRIS codes were identified for all the spills mentioned in the various spill sources. All the other information was then entered for each spilled chemical.

Field 18 indicates if the chemical had been selected in 1979 for the first 4154 Priority List (12). Field 19 recently added to store the results of the 4154 and 4155 Priority Lists generated as described in this report.

Figure A-1 shows a simple program to create or modify a data base file. It is necessary to name the data base, the file, and the fields within the file. The shaded words in Figure A-1 illustrate sample names which were used. For each field, the field type must be specified; if the field contains ASCII characters, the length must also be specified. An index indicates that the field will be used for identification. The complete set of programs which were used to build the data base in its current state are included.

```
Database Hazchem
File chemclass
Field chemname type character
  length 50 index
Field code type character
  length 3 index
Field PIRS type double
  :
End
```

FIGURE A-1. SAMPLE PROGRAM ILLUSTRATING COMMANDS USED TO BUILD THE DATABASE

PROGRAM A-1. CHEMICAL HAZARD AND SPILL HISTORY INFORMATION FILE

```
database hazchem

file chemclass

field chris_code                type character  length 3   index dups
field chemname                  type character  length 50  index
field rdc_class                 type character  length 2
field chris_class               type character  length 2
field adl_class                 type character  length 2
field kodak_class               type character  length 3
field list_4154                 type character  length 1
field haz_index                 type character  length 1
field skin_tox                  type character  length 1
field nfpa_hlth                 type character  length 1
field nfpa_fire                 type character  length 1
field nfpa_reac                 type character  length 1
field suit                      type character  length 1
field solubility                type double
field polarity                  type character  length 1
field spills83                  type integer
field mso84                     type character  length 1
field strike84                  type character  length 1
field mso_det                   type character  length 1
field pirs_percent              type double
field noaa84                    type integer
field argonne                   type character  length 1
field form                      type character  length 1
field priority54                type character  length 2
field priority55                type character  length 2
field tlv                       type double
field detector                  type character  length 10

end
```

PROGRAM A-2. NOAA CHEMREP INFORMATION FILE

```
database hazchem

file chr

field chrname       type character   length 50  index
field chrcode       type character   length 3   index dups
field drill         type character   length 1   index dups
field plan          type character   length 1   index dups

end
```

PROGRAM A-3. NRC INFORMATION FILE

```
database hazchem

file nrcinfo


field nrc_chris     type character length 3 index dups
field num85         type integer

end
```

PROGRAM A-4. CHEMICAL PROTECTIVE CLOTHING INFORMATION FILE

```
database hazchem

file product

field product_id                    type character length 8 index
field tpename                       type character length 25
field product_tpe                   type character length 2 index dups
field generic_nm                    type character length 30
field supplier_nm                   type character length 50
field product_mat                   type character length 3
field product_cond                  type character length 30
field product_supplier              type character length 3
field product_catnum                type character length 12
field product_lot                   type character length 20
field product_date                  type date
field product_thk                   type double
field product_desc                  type character length 60
field product_amt                   type character length 30

end
```

PROGRAM A-5. PERMEATION TEST METHOD INFORMATION FILE

```
database hazchem

file method

field lab_name                  type character length 30
field method_id                 type character length 8 index dups
field model_id                  type character length 10 index dups
field col_name                  type character length 10
field inj_temp                  type character length 3
field oven_temp                 type character length 3
field det_temp                  type character length 3
field temp_gradient             type character length 10
field dial_flow                 type character length 3
field gc_attn                   type integer
field gc_range                  type integer
field int_model                 type character length 10
field int_attn                  type integer
field int_thresh                type integer
field int_pkwidth               type character length 10
field int_mode                  type character length 5
field col_media                 type character length 15
field col_sys                   type character length 25
field other_cond                type character length 50
field deviations                type character length 47
end
```

PROGRAM A-6. PERMEATION TEST RESULTS INFORMATION FILE

```
database hazchem

file results

field results_notebookid        type character length 8
field results_runnum            type integer
field results_rundate           type date index dups
field results_bt1               type double
field results_bt2               type double
field results_bt3               type double
field results_btcv              type double
field results_thkcv             type double
field results_permrate          type character length 8
field results_thk               type double
field results_obsv              type character length 50
field results_matid             type character length  8 index dups
field results_methodid          type character length 8 index dups
field results_numsamples        type integer
```

PROGRAM A-6. PERMEATION TEST RESULTS INFORMATION FILE (continued)

```
field concl                    type double
field responsel                type double
field conc2                    type double
field response2                type double
field conc3                    type double
field response3                type double
field inj_vol                  type double
field det_limit                type double
field perm_chem1               type character length 25 index dups
field perm_chem2               type character length 25 index dups
field perm_chem3               type character length 25 index dups
field chemsourcel              type character length 25
field chemsource2              type character length 25
field chemsource3              type character length 25
field chemvol1                 type character length 6
field chemvol2                 type character length 6
field chemvol3                 type character length 6
field CAS1                     type character length 10
field CAS2                     type character length 10
field CAS3                     type character length 10
field t_cell                   type character length 6
field templ                    type float
field results_runlength        type double
field results_modelid          type character length 10 index dups

end
```

APPENDIX B

SCREEN ENTRY PROGRAMS

A sample program to enter two pieces of information, the chemical name and its CHRIS code, is shown in Figure B-1. Any number of different programs for screen display can be written or modified at any time. Screen displays for data entry are accessible from the main menu of the data base program.

```
Database Hazchem
Screen
{Name              [list 1]
 CHRIS code        [list 2]
}

End


Attributes
List 1 = chemname
List 2 = code
End
```

FIGURE B-1. SAMPLE PROGRAM ILLUSTRATING COMMANDS TO CREATE SCREEN ENTRY DISPLAY

PROGRAM B-1. CHEMICAL CLASSIFICATION HAZARD AND SPILL HISTORY INFORMATION ENTRY

```
database hazchem

screen


CHRIS code:    [a  ]
chemical name: [b                                                    ]
form (l,s,g) : [w]

chemical class:  R&DC [c ]   CHRIS [d ]    ADL [e ]    Kodak [f  ]

4154 list? [g]    skin toxicity? [i]

hazard assessment index: [h]

NFPA ratings:  health [j]   fire [k]   reactivity [l]

solubility parameter & polarity index: [v    ] [n]

encapsulated suit?   [m]
PIRS spills '83:     [o   ]
CG MSO response '84? [p]  CG strike team '84? [q]  MSO Detroit? [r]

PIRS % '73-'79: [s    ]    NOAA '84: [t   ]    Argonne priority: [u]


end
attributes

a = chris_code, upshift;
b = chemname;
c = rdc_class, right;
d = chris_class, right;
e = adl_class, right;
f = kodak_class, right;
g = list_4154, include = (Y,y," "), upshift;
i = skin_tox, include = (s,S," "), upshift;
h = haz_index, include = (1 to 6," ","n");
j = nfpa_hlth, include = (0 to 4," ");
k = nfpa_fire, include = (0 to 4," ");
```

PROGRAM B-1. (continued)

```
l = nfpa_reac, include = (0 to 4," ");
v = solubility;
n = polarity, include = (s,S,m,M,p,P," "), upshift;
m = suit, include = (y,Y,n,N," "), upshift;
o = spills83, right;
p = mso84, include = (y,Y," "), upshift;
q = strike84, include = (y,Y," "), upshift;
r = mso_det, include = (y,Y," "), upshift;
s = pirs_percent;
t = noaa84 ,right;
u = argonne, include = (1 to 6," ");
w = form, include = (l,s,g," ");

end
```

PROGRAM B-2. NRC INFORMATION ENTRY

```
database hazchem

screen


            NATIONAL RESPONSE CENTER DATA

                    1985 totals

    CHRIS code [11 ]

    Number of incidents [12    ]


end

attributes

11 = nrc_chris;
12 = num85;

end
```

PROGRAM B-3. PROGRAM TO ENTER PRIORITY LIST RESULTS

```
database hazchem

screen


CHRIS code:    [a  ]
chemical name: [b                                                    ]

4154 priority list? [g ]

4155 priority list? [h ]

Threshold Limit Value (mg/m3)? [l          ]

Detector ? [m          ]


end
attributes
a = chris_code, upshift;
b = chemname;
g = priority54, include = (Y,y," "), upshift;
h = priority55, include = (1,2,3,4," ");
l = tlv;
m = detector;
end
```

APPENDIX C

PROGRAMS TO IDENTIFY CHEMICALS FOR PRIORITY LISTS

PROGRAM C-1. HAZARD CLASS A CHEMICALS

```
database hazchem end
read into x chemclass
where
(haz_index=1 or haz_index=2 or skin_tox="s" or skin_tox="S"or
nfpa_hlth=4)
and form="1"
end
sort by spills83 descending
end
format
first page header
print "Priority 1 Type A Liquid chemicals"
print " arranged by spill frequency"
skip 2 lines
print "CHRIS     chemical name                #PIRS spills suit"
skip 1 line
on every record
print chris_code, 2spaces,chemname,2 spaces,spills83,2spaces,suit
on last record
print "There are a total of ", count using "###",
"  chemicals"
print "There are a total of ", total of spills83 using "###",  " spills"
end
```

PROGRAM C-2. GROUP IB CHEMICALS

```
database hazchem end
read into x chemclass
where (suit="y" or suit="Y")
and (spills83 <> 0 or mso84  <> " "
or strike84  <> " " or mso_det  <> " "
or pirs_percent > 0 or noaa84 > 0 or argonne < > " ")
and not (haz_index=1 or haz_index=2 or skin_tox="s" or skin_tox="S"or
nfpa_hlth=4)
and (haz_index=3 or nfpa_hlth=3)
and form="1"
end
sort by spills83 descending
end
format
first page header
print "Encapsulated suit chemicals with a spill history"
print " Group IB arranged by chemical form and class"
skip 2 lines
```

```
print "CHRIS     chemical name                          PIRS spills,index,nfpa"
skip 1 line
on every record
print chris_code, 2spaces,chemname,spills83,1space,haz_index,1space,nfpa_hlth
on last record
print "There were a total of  ",total of spills83 using "###","spills."
skip 2 lines
print "There are a total of ", count using "###",
"  chemicals"
end
```

PROGRAM C-3. GROUP IIIB CHEMICALS

```
database hazchem end
read into x chemclass
where (suit < > "y" and suit < > "Y")
and (spills83  > 0 or mso84  < > " "
or strike84  < > " " or mso_det < > " "
or pirs_percent >  0 or noaa84 >0 or argonne < >  " ")
and not (haz_index=1 or haz_index=2 or skin_tox="s" or skin_tox="S"or
nfpa_hlth=4)
and (haz_index=3 or nfpa_hlth=3)
and form="1"
end
sort by spills83 descending
end
format
first page header
print "Non-encapsulated suit chemicals with a spill history"
print " Group IIIB arranged by chemical form and class"
skip 2 lines
print "CHRIS     chemical name                          PIRS spills,index,nfpa"
skip 1 line
on every record
print chris_code, 2spaces,chemname,spills83,1space,haz_index,1space,nfpa_hlth
on last record
print "There were a total of  ",total of spills83 using "###","spills."
skip 2 lines
print "There are a total of ", count using "###",
"  chemicals"
end
```

PROGRAM C-4. GROUP IC CHEMICALS

```
database hazchem end
read into x chemclass
where (spills83  > 0 or mso84 < >  " "
```

PROGRAM C-4 (continued)

```
or strike84 < > " " or mso_det < > " "
or pirs_percent  > 0 or noaa84  > 0 or argonne   < >" ")
or argonne < >  " ")
and (suit="y" or suit="Y")
and not (haz_index=1 or haz_index=2 or skin_tox="s" or skin_tox="S"or
nfpa_hlth=4 or haz_index=3 or nfpa_hlth=3)
and form="1"
end
sort by spills83 descending
end
format
first page header
print "Priority IC liquid chemicals"
print " arranged by frequency of spill PIRS 73-83 compilation"
skip 2 lines
print "CHRIS     chemical name                  83PIRS comp,hazard
code,NFPA,skin"
skip 1 line
on every record
print chris_code, 2spaces,chemname,2
spaces,spills83,1space,haz_index,1space,nfpa_hlth,1space,skin_tox
on last record
skip 1 line
print "There were a total of  ",total of spills83 using "###","spills."
skip 1 line
print "There are a total of ", count using "###",
"  chemicals"
end
```

PROGRAM C-5. 4154 PRIORITY LIST CHEMICALS BY PIRS OCCURRENCES

```
database hazchem end
read into y chemclass chr
joining chris_code= optional chrcode
where
chris_code < > "  "
and (haz_index="1" or haz_index="2" )
and ((chrcode   < > " " or spills83  > 0 or pirs_percent  > 0))
end
read into x chemclass chr
joining chris_code= optional chrcode
where
chris_code < > "  "
and ((spills83  4)
or (spills83 > 1 and chrcode < > " ")
or (pirs_percent  > 0.1 and chrcode  < > " "))
and haz_index="3"
```

PROGRAM C-5 (continued)

```
end
assign a=y union x
end
read into z chemclass chr
joining chris_code= optional chrcode
where
chris_code < > "  "
and (spills83  >  10 or pirs_percent   > 1.0)
or (chrcode  < > " " and spills83  > 5))
and not(haz_index="1" or haz_index="2" or haz_index="3")
end
assign b=z union a
end
sort by spills83 descending
end
format
first page header
print " Priority List 4154 - Hazardous Chemicals"
print " These chemicals are listed in order of PIRS occurences"
skip 2 lines
print "CHRIS     chemical name                                    PIRS spills "
skip 1 line
on every record
print chris_code, 1 space,chemname,spills83
on last record
skip 2 lines
print "There are a total of ", count using "###",
"  chemicals"
print"This accounts for ", total of (spills83) using "####"  , "chemical
spills  "
end
```

PROGRAM C-6. 4154 PRIORITY LIST GROUPED BY CHEMICAL STATE AND HAZARD INDEX

```
database hazchem end
read into y chemclass chr
joining chris_code= optional chrcode
where
chris_code  < > "  "
and (haz_index="1" or haz_index="2" )
and (chrcode   < >  " " or spills83  > 0 or pirs_percent  > 0)
end
read into x chemclass chr
joining chris_code= optional chrcode
where
chris_code  < > "  "
and (spills83  > 4)
```

PROGRAM C-6 (continued)

```
or (spills83 > 1 and chrcode < > " ")
or (pirs_percent > 0.1 and chrcode  < > " "))
and haz_index="3"
end
assign a=y union x
end
read into z chemclass chr
joining chris_code= optional chrcode
where
chris_code < > "  "
and ((spills83 >  10 or pirs_percent >  1.0)
or (chrcode  < > " " and spills83  > 5))
and not(haz_index="1" or haz_index="2" or haz_index="3")
end
assign b=z union a
end
sort by form haz_index
end
format
first page header
print "  Priority List 4154 Hazardous Chemicals"
print " These chemicals are grouped into solids, liquids, and gases"
print "  and listed by hazard index"
skip 2 lines
print "CHRIS     chemical name                          chemical  hazard   "
skip 1 line
on every record
print chris_code, 2spaces,chemname, form,5 spaces,haz_index
on last record
skip 2 lines
print "There are a total of ", count using "###",
"  chemicals"
end
```

APPENDIX D

4155 PRIORITY LIST CHEMICALS IN PRIORITY GROUPS

TABLE D-1

KEY TO DETECTOR CODES AND COLLECTION MEDIA FOR PERMEATING TESTING

Method of Detection	Collection Medium
Gas Chromatographic Techniques	
F = Flame Ionization Detector	air
E = Electron Capture Detector	air
H = Hall Detector	air
FP = Flame Photometric Detector	air
Colorimetric Techniques	
C = Colorimetric standard method or commerical test kit based on method	water
Ion Chromatography	
A = Anion Column	water
Cat = Cation Column	water
Other Techniques	
SI = Specific ion electrodes	water
P = Polarography	water
IR = Infrared spectrographic analysis	air

TABLE D-2

Group I-IVA Liquid Chemicals
Arranged by Number of PIRS Spills ('73-'83)

PS = PIRS spills
S = Need for encapsulated suit (Y=Yes)

CHRIS	CHEMICAL NAME	DETECTOR CODE	PS	S
BNZ	benzene	F	91	Y
TOL	toluene	F	81	
STY	styrene	F	59	
CRS	cresol	F/C	33	
PHN	phenol	F/C	26	
FMS	formaldehyde	C	17	Y
MTC	methyl chloride	H/E	15	
ACN	acrylonitrile	F	12	Y
NAC	nitric acid	A/C	8	Y
VAM	vinyl acetate	F	8	Y
VCI	vinylidene chloride	H/E	8	Y
CBT	carbon tetrachloride	H/E	6	
HFA	hydrofluoric acid	A/C	6	Y
TCL	trichloroethylene	H/E	5	Y
ADN	adiponitrile	F	4	Y
CRF	chloroform	H/E	3	Y
EAM	ethylamine	F	3	Y
ANL	aniline	F	2	Y
BAN	n-butyl alcohol	F	2	
BCL	benzyl chloride	F	1	Y
BVA	t-butyl amine	F	1	Y
CSA	chlorosulfonic acid	A	1	Y
EPC	epichlorohydrin	H/E	1	Y
HCN	hydrogen cyanide	SI/C	1	Y
MPT	methyl parathion mp=65F	FP	1	Y
NTB	nitrobenzene	E	1	Y
PTO	parathion	FP	1	Y
POX	propylene oxide	F	1	
TEC	1,1,2,2-tetrachloroethane	H/E	0	Y
DPC	1,3-dichloropropene	H/E	0	
DOX	1,4-dioxane	F	0	
NPP	2-nitropropane	F/FP	0	Y
ALC	allyl chloride	H/E	0	Y
BRX	bromine	C/P	0	Y
CBB	carbon disulfide(bisulfide)	E	0	Y
CPL	chloropicrin	H/E	0	Y
CTA	crotonaldehyde	F	0	Y

TABLE D-2 (continued)

CHRIS	CHEMICAL NAME	DETECTOR CODE		PS	S
DEE	dichloroethylether	H/E		0	Y
DIA	diisopropylamine	F		0	
DSF	dimethyl sulfate	FP		0	Y
EDB	ethylene dibromide	H/E		0	Y
EDC	ethylene dichloride	H/E		0	Y
GTA	glutaraldehyde	F		0	Y
HFX	hydrogen fluoride	C/A		0	Y
IPP	isopropylamine	F		0	Y
MFA	motor fuel anti-knock compounds (lead alkyls)	E		0	Y
TLI	o-toluidine	F		0	
STC	silicon tetrachloride	E		0	Y
TDI	toluene diisocyanate	F		0	Y
ACY	acetone cyanohydrin	F		0	Y
BAM	n-butylamine	F		0	Y

There are a total of 51 chemicals.

There are a total of 398 spills.

TABLE D-3

Group IB Encapsulated Suit Liquid Chemicals with a Spill History
Arranged by Number of PIRS Spills ('73-'83)

PS = PIRS spills
H = Hazard Index
N = NFPA classification

CHRIS	CHEMICAL NAME	DETECTOR CODE	PS	H	N
SFA	sulfuric acid	A/C	128	3	3
AAC	acetic acid	F	13	3	2
ACT	acetone	F	11	3	1
EAC	ethyl acrylate	F	11	3	2
ACR	acrylic acid	F	10	3	3
MIK	methyl isobutyl ketone	F	5	3	2
AAD	acetaldehyde	F	4	3	2
TCE	trichloroethane	H/E	4	3	2
ACA	acetic anhydride	IR	2	3	2
ATN	acetonitrile	F	2	3	2
ALA	allyl alcohol	F	2	3	3
DPP	dichloropropane	F/E	2	3	2
ACC	acetyl chloride	IR	1		3
ARL	acrolein	F	1		3
MAM	methyl acrylate	F	1	3	2
TEL	tetraethyl lead	E	1		3
XYL	xylenol	F	1	5	3
DNA	di-n-propylamine	F	0	5	3
HDZ	hydrazine	P/C	0		3
PRA	n-propyl amine	F	0	4	3
OLM	oleum	A/C	0	3	3
PPT	phosphorus trichloride	E	0		3
CSS	sodium hydroxide solution	Cat	0	3	3
TML	tetramethyl lead	E	0		3

There were a total of 199 spills.

There are a total of 24 chemicals in this group.

TABLE D-4

Group IC Encapsulated Suit Liquid Chemicals with a Spill History
Arranged by Number of PIRS Spills ('73-'83)

PS = PIRS spills
H = Hazard index
N = NFPA index

CHRIS	CHEMICAL NAME	DETECTOR CODE	PS	H	N
PCB	polychlorinated biphenyl compounds	E	92		
CDN	chlordane	E	3		
HPO	hydrogen peroxide 60%	C	2		2
MLT	malathion	FP	2		
BTR	n-butyraldehyde	F	2	5	2
SHR	sodium hydrosulfide solution	C/A/Cat	2	5	
ETO	ethion	FP	1		
ETC	ethylene cyanohydrin	F	1	5	2
NLD	naled	E	1		
PPO	phosphorus oxychloride	C/A	1		
SFM	sulfur monochloride	C/A	1		2
TEP	tetraethyl pyrophosphate	FP	1		
CCT	creosote	F	0	5	2
CMH	cumene hydroperoxide	F	0		1

There were a total of 109 spills.

There are a total of 14 chemicals in this group.

TABLE D-5

Group IIIB Non-encapsulated Suit Liquid Chemicals with a Spill History
Arranged by PIRS Spills ('73-'83)

PS = PIRS spills
H = Hazard assessment index
N = NFPA classification

CHRIS	CHEMICAL NAME	DETECTOR CODE	PS	H	N
XLM	xylene (meta-xylene as model)	F	92	3	2
EGL	ethylene glycol	F	23	3	1
PAC	phosphoric acid	C/A	22	3	2
CHX	cyclohexane	F	17	3	1
MAL	methyl alcohol	F	11	3	1
NTM	naphthalene	F	10	3	2
EAL	ethyl alcohol	F	9	3	0
MEK	methyl ethyl ketone	F	6	3	1
EDA	ethylenediamine	H/E	5	3	3
TPT	turpentine	F	5	3	1
DCM	methylene chloride	H/E	4	3	2
HXA	n-hexane	F	4	3	1
ETB	ethyl benzene	F	3	3	2
MMM	methyl methacrylate	F	3	3	2
DEA	diethanolamine	F	2	3	
CRB	chlorobenzene	H/E	1	3	2
ETA	ethyl acetate	F	1	3	1
EET	ethyl ether	F	1	3	2
FFA	furfural	F	1	3	2
BCN	n-butyl acetate	F	1	3	1
BTC	n-butyl acrylate	F	1	3	2
PAL	n-propyl alcohol	F	1	3	2
PNA	propionic acid	F	1	3	2
GAT	gasoline	F	0	3	1
IPA	isopropyl alcolol	F	0	3	1
NSS	naphtha	F	0	3	2
TTE	tetrachloroethylene	H/E	0	3	2

There were a total of 224 spills.

There are a total of 27 chemicals in this group.

END

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DTIC